Women's Football: An Examination of Factors That Influence Movement Patterns

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Abstract

The popularity and professionalism of women’s football has increased in conjunction with participation rates over the last 10 years, with projected female participation rates to double worldwide by 2026. Scientific interest has also increased, in part due to Fédération Internationale de Football Association now allowing Global Positioning System (GPS) units to be worn during all competitive matches, resulting in investigations into the match demands of women’s football. Therefore, the purpose of the present review is to provide a summary of the literature specific to the movement patterns of women’s football matches.

Contemporary scientific investigation utilising GPS match data has led to a greater understanding of the movement patterns of football. Greater emphasis has been placed on high-speed running and sprinting during matches, due to the strong link to scoring opportunities and being a distinguishing factor between international and national along with elite and sub-elite competition levels. Further research however, is warranted in regard to accelerations and decelerations, given the high metabolic and mechanical loads and contribution to high-speed running and sprinting. With an influx of research into the movement patterns of match-play, investigators have begun to examine factors affecting match performance such as positional demands, age, level of competition, opponent, score-line, and phase of the game. An understanding of the factors that influence match demands is vital to ultimately be able to understand the effects on performance and how manipulating these factors may improve football performance and reduce the risk of injury.

Key words: female, movement patterns, soccer, GPS, team-sports

INTRODUCTION

Women's sports such as soccer, referred to hereafter as football, have received increased attention through highly publicised events such as the Olympics and the Football World Cup. The 2015 Women's Football World Cup in Canada highlighted the growing popularity of the sport around the world, with record attendances of 1.35 million people and TV viewing audiences of more than 750 million (17). Participation rates in 2015 confirmed that 30 million women and girls play football worldwide, equating to an increase of 32% since 2010 (16). In a 2018 report released by The Fédération Internationale de Football Association (FIFA) "Strategy for Women's Football", women's participation rates were projected to double to 60 million worldwide by 2026 and efforts to increase women's participation rates were centred around the 2019 Women's Football World Cup in France (17).

Burgeoning investment in women's football (17), particularly around performance based research, has seen an increase in the professionalism of the sport as well as a decrease in the performance gap between male and female football (17). Literature reviews, (9, 29) conducted in 2014 by leading researchers in women's football have focused on the movement patterns of the female game and player characteristics such as anthropometry, VO_{2max}, speed and power. However, since these reviews were undertaken, FIFA has introduced law changes to allow Global Positioning System (GPS) units to be worn during all competitive matches (15). These changes have created an increased opportunity to further understand and research the demands of match-play by examining the movement patterns of players during matches. In the current review the authors have identified 15 new research articles in addition to the previous 2014 reviews (9, 29), quantifying the movement patterns of

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match-play, with the majority of these studies using GPS units. As a result of the law changes and the increased scientific attention around match-play, an updated review is timely. Specifically, the purpose of the present review is to provide an updated summary of the literature specific to the movement patterns of women's football matches. As scientific research within women's football continues to increase, so too does the scientific understanding of match demands and factors contributing to performance. These factors have been included to provide further understanding not just around the basic movement patterns but also the variables that seem to most heavily influence match demands.

All statements and descriptions in the current review are only made in reference to women's football. There are numerous research articles pertaining to the movement patterns of men's football for interested readers (3, 4, 25, 33, 36-38, 40). Furthermore, when referring to high-speed running and sprinting in the current review, speed zones of 16-20 $km \cdot h^{-1}$ and > 20 $km \cdot h^{-1}$ are utilised respectively, unless otherwise stated. The definitions used for each speed zone were selected as they are the most commonly used within the literature (16, 43, 44, 49).

The validity and reliability of GPS improves with an increase in sampling frequency from 5 Hz to 10 Hz for all movement pattern measures of acceleration, deceleration and distance in speed zones. No additional benefits, however, are found with an increased sampling rate of 15 Hz (39). Global positioning system units sampling at 10 Hz provide a valid measure of high-speed running distance (coefficient of variation (CV) 1.9%) and acceleration (CV 3.6-5.9%), while sprinting distance and deceleration tend to be less valid (CV ~ 10%) (39). Similar result are also evident for reliability of 10 Hz units with acceleration (CV 1.9-4.3%) and deceleration (CV 6%),

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displaying good to moderate interunit reliability (39). Further detailed information on the data collection process and GPS validity and reliability for interested readers can be found in the following articles (5, 39).

Movement Patterns

Football is a sport that requires intermittent physical efforts, as well as high levels of agility, speed, and endurance (1, 8, 34). To be successful, players need to perform repeated high-intensity efforts including high-speed running, sprinting, changes in direction, and football specific skills such as passing, tackling and goal shooting (13, 27, 42, 44). The technical and tactical demands are not the focus of the current review; however, it is important to acknowledge the element of skill required to play football. Indeed, it has been identified that the most significant activities that affect the outcome of a match include one-on-one contests in attack and defense, passing accuracy, and effective execution of dead-ball situations, which include corners, free kicks and throw-ins (42).

The movement patterns of football have been researched widely, providing a greater understanding of the external loads of football (26, 34, 44) (Table 1). The total distance covered has typically reflected the movement patterns of match-play, with elite players shown to cover total distances of ~ 10,000 m (1, 8, 20, 44). Recently, greater focus on the amount of distance covered during high-speed running and sprinting has been evident in the literature, likely a result of the strong link to football specific demands of one-on-one contests for the ball and scoring opportunities (8, 27). High-speed running has been shown to be highly variable between matches across different playing positions, with a reported CV of 33% (44). This means football players may perform anywhere between 600 and 1000 m of high-speed

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running each match (34, 44). The greatest variability in match performance is the number of sprint efforts, with a CV of 53% (44) and the total distance covered varying from 300-600 m (2, 16, 27, 34). In terms of distance covered during high-speed running (12-19 $km \cdot h^{-1}$) and sprinting (> 19 $km \cdot h^{-1}$) efforts, research findings suggest that the majority of these high-speed or sprinting efforts are less than 10 m, with maximum distances of ~ 30 m (26, 27).

High-speed running and sprinting are particularly important in game situations, where the ability to perform a repeated high-intensity effort is beneficial to pressuring the opposition, regaining possession or creating scoring opportunities. Approximately 79% of the high-speed runs (12-19 $km \cdot h^{-1}$) and 35% of sprints (> 19 $km \cdot h^{-1}$) performed in matches were considered repeated efforts (defined as two or more efforts with less than 20 s between each one) (27). The most common number of repeated efforts performed is two, indicating that players frequently perform two high-intensity efforts within 20-30 s during a game (7, 27).

The majority of high-speed running (12-19 $km \cdot h^{-1}$) and sprinting (> 19 $km \cdot h^{-1}$) bouts occur over distances of less than 10 m (8, 27), highlighting the importance of accelerations and decelerations to high-speed running and sprinting and the overall movement patterns of football matches. Accelerations and decelerations also present the highest demands on players, with the metabolic cost of accelerations and decelerations higher compared to running at a constant velocity (32). Moreover, the mechanical load per metre is higher for accelerations (28%) and decelerations (65%), in comparison to all other match activities (6).

Despite the importance of accelerations and decelerations to performance and training load management, there have been limited studies that have examined these parameters in detail. During international matches, players have been shown to perform ~ 160 accelerations (> 2.26 $m \cdot s^{-2}$) (30, 44), while another study utilising the same level of competition found players undertook over 200 accelerations (> 1 $m \cdot s^{-2}$) and 170 decelerations (< -1 $m \cdot s^{-2}$) (34). Interestingly, during national level matches it was concluded that players performed over 420 accelerations (> 2 $m \cdot s^{-2}$) and 430 decelerations (< -2 $m \cdot s^{-2}$) per match (26). The acceleration and deceleration values presented are highly variable across all of the studies, which is somewhat surprising considering the same level of competition was investigated (26, 30, 34, 44). The large differences between studies in acceleration and deceleration movement patterns may be attributed to the data collection methods, particularly the acceleration and deceleration thresholds and sample rates utilised. The threshold for a single acceleration was defined using different cut-off values across the four studies, while the deceleration threshold included two different cut-off values across the two studies. The inconsistent definitions used to describe an acceleration and deceleration during match-play limits the direct comparisons that can be made across the studies presented in the current review. The study reporting the highest acceleration and deceleration values utilised Optical Player Tracking sampling at 25 Hz (26) in comparison to the other studies which utilised GPS units operating at 10 Hz (30, 34, 44). Despite the difficulty in directly comparing the results of both studies, results indicate that higher sample rates may be more useful in quantifying the true number of accelerations and decelerations occurring during match-play.

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Accelerations (> 2 m·s^{-2}) on average occur over a distance of 4.3 m, while decelerations (< -2 m·s^{-2}) occur over a distance of 4 m (26), demonstrating that acceleration and deceleration actions are performed over short intense efforts. Given the limited distances that accelerations and decelerations occur over, it is apparent that footballers need to be able to apply or absorb high forces during each step, particularly during important match events such as reaching the ball first or trying to limit the movement of an opposition player. The majority of accelerations have been shown to occur from a low starting speed (< 12 km·h^{-1}), while decelerations have been shown to be more variable occurring across a range of low and high-speeds (12-19 km·h^{-1}) (26). This initial speed before an acceleration or deceleration is important, as this will affect the resulting magnitude of change in speed. Maximal acceleration has been shown to be dependent on the initial velocity, with linear decreases in maximal acceleration capacity with increasing starting speeds (41). Therefore, it may be useful for sport scientists to further categories each acceleration and deceleration based on the velocity of the preceding movement (41).

While it is commonly accepted that high total distances result in high metabolic demands during football, it is also apparent that the higher number of accelerations and decelerations over short periods of time mean football players likely experience high mechanical loads during a match (6, 32, 46). Consequently, football players need to be able to perform repeated, explosive and powerful running movements if they are going to be successful.

TABLE 1 HERE

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Factors Influencing Movement Patterns

The movement patterns of an individual player can change from match-to-match and are typically dependent on (i) their position, (ii) their age, (iii) the level of competition, (iv) the opponent, (v) the score-line, and (vi) phase of the game. Other intrinsic factors such as motivation or fatigue can also affect player movement.

TABLE 2 HERE

Positional Demands

Positional differences in player movement patterns are known to exist in football (1, 20). Midfielders and attackers cover greater total distances and demonstrate higher work rates compared to defenders (1, 20). Midfielders greater total distance in comparison to defenders is a result of them undertaking more high-speed running (12-19 $km \cdot h^{-1}$) and sprinting (> 19 $km \cdot h^{-1}$) (20) (> 25 $km \cdot h^{-1}$) during a match (1). Several differences in the movement patterns of matches have been highlighted between central defenders and wide defenders, as well as between central midfielders and wide midfielders (Table 2) (8). The large variation that has been demonstrated within the generic defenders and midfielders positional groups, suggest that positional groups need to be further subcategorised based on central and wide players' differing location on the field and positional roles (8). In previous literature, outfield positions have typically been divided into five positional groups: central defenders, wide defenders, central midfielders, wide midfielders and attackers (12).

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Central defenders have been reported to perform less distance at high-speed (16, 31), a lower relative distance (11) and exhibit the fewest repeated high-intensity activity bouts over shorter distances and durations compared to all other positions (7). Central midfielders perform a similar number of efforts and distance sprinting to central defenders, possibly due to the limited space and congestion in central areas compared to wider or attacking players (11, 16). Central midfielders, however, perform similar amounts of high-speed running in comparison to wide midfielders, wide defenders and attackers (16) and more high-speed running (18-23 $km \cdot h^{-1}$) than central defenders (11). Both wide and central midfielders tend to have shorter recovery times (< 20 s) between high-intensity activity, with longer recovery times (> 60 s) more common for central defenders (7). The positional role of midfielders requires support for both attacking and defensive actions, limiting the recovery time between high-intensity activity (7).

Wide players perform a greater number of longer sprints over distances greater than 15 m in comparison to all other playing positions (8, 16). Moreover, attackers perform more high-speed runs (18-23 $km \cdot h^{-1}$) and sprints (> 23 $km \cdot h^{-1}$) than any other position (11), and more repeated high-intensity activity than defensive players (7). Straight line sprints are the most common action prior to scoring a goal, for both the goal scorer and the assisting player (13), highlighting the importance of these high-intensity activities for attacking players.

Despite all the differences in positional demands, particularly for central defenders, there are no positional differences for the total number of accelerations (> 1 $m \cdot s^{-2}$, > 2 $m \cdot s^{-2}$) and decelerations (< -1 $m \cdot s^{-2}$, < -2 $m \cdot s^{-2}$) (26, 34). The differences in

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positional demands that are observed between accelerations and decelerations are evident for initial and final velocities as well as maximum distance in which they are performed (26). Wide midfielders and attackers perform more accelerations from an initial speed of 13-19 $km \cdot h^{-1}$ and finishing at 13 $km \cdot h^{-1}$ or above, when compared to central defenders (26). The maximum distance achieved while accelerating is reported to be 6.6 m for central defenders and 8.4 m for wide defenders (26). In contrast, deceleration demands are similar for central defenders and central midfielders with a maximum distance of 7.5 m, which is shorter compared to attackers who demonstrate deceleration distances of 10.5 m (26). The shorter deceleration distances of central midfielders and central defenders may be a result of reduced space for central players, therefore limiting the top speeds that they can reach before being required to decelerate.

Age

Investigations into the differences between age groups in international matches highlights the changes that occur with maturation and the required development if younger players are going to progress to elite players. Research comparing U17, U20 and senior elite players found a progressive increase in total distance and high-intensity activities, including high-speed running, sprinting, accelerations (> 1 $m \cdot s^{-2}$) and decelerations (< 1 $m \cdot s^{-2}$) (34). Interestingly, the greatest difference between age groups was for the number of decelerations performed during matches. Effect sizes between the age groups increased between the elite and U20 (1.15-4.04) and elite and U17 (2.79-5.57) comparisons across all playing positions. There are numerous factors accounting for this discrepancy; however, in general the intensity of the matches and the physical attributes of the players is the most plausible reason for

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the observed difference (34). Based on the large differences in decelerations during a match between age groups, a focus on improving the technique and physical capacities required for deceleration (19, 22), would improve the younger girls ability to decelerate during a match and minimise the disparity between the younger and senior age groups. Comparisons between age groups also highlights the need to develop a player's capacity to perform high-intensity activities such as high-speed running, sprinting and accelerations.

Competition Level

The difference between national and international level matches has not been investigated extensively, with only two GPS based studies directly comparing standards of play (1, 18). While it is typically assumed that higher standards of competition elicit faster and more intense movement patterns, specifically what movement pattern variables are higher is not yet conclusive and requires further research (1). Current research has demonstrated that players cover similar total distances during national and international matches (1), however, when distance is examined in relation to speed zones there are differences between competition levels for distance covered during high-speed running and sprinting. For example, international players covered 13% more distance at high-speed running (18-25 $km\cdot h^{-1}$) compared to national-level players (1). Further examination of the data reveals the differences are a result of significantly more high-speed runs (18-25 $km\cdot h^{-1}$) for international players, rather than high-speed running occurring over longer durations or distances (1). Interestingly, there was no difference between competition levels for the number of sprints (> 25 $km\cdot h^{-1}$) performed; however, international players covered 14% more distance sprinting in the first half in comparison to national-level

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players (1). Competition level was also distinguished between elite, sub-elite, non-elite players with greater distance covered and percentage of distance covered at high-speed running (15-18 $km \cdot h^{-1}$) and sprinting (> 18 $km \cdot h^{-1}$) for elite players (45). Similar results were also found for repeated sprints during match-play, with international and national players performing a similar number of efforts, although international players had a greater sprint duration and a shorter recovery duration between repeated sprint efforts compared to national players (18). The number of efforts along with the total distance covered in the high-speed running and sprinting speed zones provides a better indication of the difference in movement patterns between competition levels, than one measure alone.

Opponent and Match Outcome

The movement patterns of a match are influenced by multiple factors, including the quality of the opposition team, the outcome of the match, and the score-line within a match (11, 43). Winning against higher ranked teams saw an increase of 10% for the total number of accelerations (43). For a draw, a moderate increase of 19% for high-speed running and an increase of 10% in the number of accelerations was demonstrated when playing a lower ranked team compared to a higher ranked team (43). These findings suggest that when playing lower ranked teams, where the expectation is to win the match, players tend to be more attacking and perform more high-intensity running. Significant differences have been observed for the relative distance covered sprinting, with the greatest movement patterns observed when losing a match (49). It is thought that an increased effort to score may explain this difference, however, it could also be a result of constant defending. Thus, it is

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apparent that a players movement patterns and behaviours are altered due to the situation of a game (21).

The outcome of a match has also been shown to alter the movement patterns of players (21, 43). The score-line within a match may also provide further insight into how movement patterns are affected. Scoring the first goal is critical in winning football matches, as the team that scores first is five times more likely to win (21). The importance of scoring first may explain why in general the movement patterns were higher when it was a 0-0 draw compared to all other game situations (11). The greater movement patterns in a 0-0 score-line were also reflected by ~ 10% higher total distance and relative distance for central defenders and central midfielders and higher player load for attackers (~ 6%) and wide defenders (~ 12%) (11).
When trailing the opposition team compared to a 0-0 draw, central midfielders performed less accelerations and decelerations resulting in a small reduction (16%) in player load (11). Central defenders high-speed running (18-23 $km \cdot h^{-1}$) was 54% higher when trailing as opposed to leading, however, no differences were observed when trailing compared to when the match was drawn 0-0 (11). Interestingly, attackers were the only position that had no change in movement patterns regardless of the game situation (11), which may reflect their purpose to score no matter the score-line. Game data comparing the outcome of the match and the score-line within a match suggested that tactics throughout the different scenarios may also have a role in influencing movement patterns during a match (11, 43).The large degree of within-game variation in score may contribute to and explain the significant degree of disparity between games for many of the GPS-derived statistics.

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Phase of the Game

As outlined in the current review, football players are exposed to high metabolic and mechanical demands throughout a match, which can result in fatigue and ultimately performance decrements (10, 28). During elite football matches, the total distance covered during the first half decreased by ~ 5% in the second half (2, 20, 27). Changes in total distance can be attributed to a significant decrease in the amount of high-speed running and sprinting (8, 27, 31), a decrease in the number of accelerations and decelerations, and an increase in the mean time between high-intensity efforts in the second half (26). High-speed running (12-19 $km \cdot h^{-1}$) and sprinting (> 19 $km \cdot h^{-1}$) distances were 13% and 14% greater, respectively, in the first half compared to the second half (27). Sprint distance deteriorations in the second half have been demonstrated to be as high as 21%, however, the sprint threshold was defined as > 25 $km \cdot h^{-1}$, which may explain the larger discrepancy in comparison to other studies (47). The greater distances covered at high-speed running (12-19 $km \cdot h^{-1}$) and sprinting (> 19 $km \cdot h^{-1}$) in the first half compared to the second was a result of 15% more high-speed runs and 17% more sprints (27). Similar results were observed for higher sprint velocity thresholds (> 25 $km \cdot h^{-1}$) whereby the distance covered per sprint remained the same from half to half, but the number of sprints was reduced in the second half (47). Repeated high-intensity activity followed a similar trend in terms of decreases, with movement patterns being reduced during the second half. Specifically, fewer efforts were performed and a greater recovery time between bouts was reported in the second half compared to the first (7). Anderson et al (1), however, found no significant differences in the distance covered during sprinting (> 25 $km \cdot h^{-1}$) between the two halves. The lack of significant

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differences between halves may be a result of the sample size, in which only one to three matches per player were analysed.

Decreases between halves may also be attributed to 'mental fatigue' in addition to physical fatigue. Mental fatigue may interfere with the processes that limit physical ability, increasing the perceptual effort and drive impulse to perform high-intensity activity (33). Central fatigue is thought to play a role in technical performance and therefore would affect the movement patterns of the game (24, 28). It is well accepted that fatigue is multi-factorial process with no one explanation completely accounting for the reduction in performance within a match.

Dividing a 90-minute football match into 15-minute intervals rather than two 45-minute halves may allow for fluctuations and temporal patterns of fatigue to be better identified and understood. When football matches were divided into 15-minute intervals, total distance and distance at high-speed (> 12 $km \cdot h^{-1}$) (20) were greater in the first 0-15 minute period than any other 15-minute interval (26). Accelerations and decelerations also peaked during the first 15-minute interval, with the lowest mean and maximum time between acceleration (> 2 $m \cdot s^{-2}$) and deceleration (< -2 $m \cdot s^{-2}$) efforts. Interestingly, sprint distance (> 19 $km \cdot h^{-1}$) didn't significantly change during the 15-minute intervals of a match despite changes between the halves (20, 27). Significant reductions in the total distance and distance covered at high-speed running (12-19 $km \cdot h^{-1}$) were found for the 60-75 minute and 75-90 minute period in comparison to the first 0-15 minutes (20). During the last 75-90 minute period, players covered ~ 25% less high-speed distance compared to the 0-15 minute interval (1, 20, 35), despite the studies using different definitions to characterise

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high-speed running (> 12 km·h^{-1} (20); > 15 km·h^{-1} (35); > 18 km·h^{-1} (1)). Reductions as large as 35% have also been demonstrated for high-speed running distance between the first and last 15-minute intervals; however, a speed threshold of 20-25 km·h^{-1} (8) was used to define high-speed running, which is more commonly used to define sprinting in football players (20, 27, 34). Through the examination of movement pattern changes between halves and 15-minute intervals, it is apparent that the high metabolic and mechanical demands of football matches cause physiological changes that tend to reduce physical performance capacities.

It is important to acknowledge that reductions in match performance may not only be due to fatigue, but also other factors such as the technical and tactical requirements and situational variables changing near the end of a match. Such situational variables may include tactics of players slowing the game down and increasing the number of stoppages or breaks within the game, particularly in the second half. The effective playing time has been demonstrated to be significantly greater in the first half compared to the second half during elite men's football matches (23, 28). Teams may opt to constantly attack by continually going forward, or maintain possession and sit back in defence to limit the space of the opposition in their attacking half (11, 43). Other strategies employed, include players conserving energy through decision making about when or when not to become involved in play (28, 33).

It is evident that the use of GPS units during competitive matches has contributed to our understanding of the movement patterns of football players (15). Both accelerations and decelerations until recently, have received little formal investigation during elite football. Given the high metabolic and mechanical loads

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associated with accelerations and decelerations (6, 32, 46), it would be of value from a performance and injury reduction perspective to more thoroughly examine these important aspects of football.

The current review also highlights the importance of considering player position when examining player performance. Positional requirements are strongly influenced by technical and tactical roles and should be included in future investigations of football performance. Other factors that warrant further, more rigorous investigation, include the effect of playing standard (i.e. international vs national) and age on movement patterns and overall playing performance.

PRACTICAL APPLICATIONS

Practical recommendations from the present review include:

- Coaches and practitioners need to individualise training based on playing position due to the inherited differences observed. Specific considerations including the differences between central and wide players within the traditional midfield and defenders' positional groups.
- Speed can be used as an important talent identification variable based on observed speed increases being associated with higher levels of competition. Increased high-intensity movement patterns will also have ramifications for training load monitoring and ensuring players have been adequately exposed to this increased stimulus.
- Coaches and practitioners should emphasise deceleration training for younger players, not only from an injury reduction perspective but improved performance. A focus on deceleration technique and the physical capacities

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such as eccentric strength, will assist in preparing younger footballer for high levels of football.

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Table 1. A summary of the movement patterns of football match-play.

Study	Year	Matches analysed	Subjects/ Nationality/ Competition level	Method of data collection	Total distance (m)	HSR (m)	Sprinting (m)	Accelerations (n)	Decelerations (n)
						(> 18 km·h^{-1})	(> 25 km·h^{-1})		
Andersson et al (1)	2010	3 International 3 National	17 Swedish/ Danish National/ International	Time motion analysis	National				
					9700 ± 1400	1330 ± 900	221 ± 45		
					International				
					9900 ± 1800	1530 ± 100	256 ± 57		
					1st Half	820 ± 50	136 ± 3		
					2nd Half	720 ± 50	120 ± 3		
						(15-21 km·h^{-1})	(> 21 km·h^{-1})		
Bradley et al (2)	2014	Not provided	59 European National	Amisco Pro (25 Hz)	10754 ± 150*	1358 ± 50*	291 ± 24*		
					1st Half				
					5486 ± 80*	705 ± 27*	148 ± 14*		

					2nd Half		
					5267 ± 91*	653 ± 28*	142 ± 15*
						(20-25 km·h^{-1})	(> 25 km·h^{-1})
Datson et al (8)	2017	10	107 13 National teams International	Prozone Sports (25 Hz)	10321 ± 859	608 ± 181	168 ± 82
						RS	RS
Datson (7)	2016	10	107 13 National teams International	Prozone Sports (25 Hz)		(20-25 km·h^{-1}) (n) 33 ± 10	(> 25 km·h^{-1}) (n) 1.1 ± 1.1
						(18-23 km·h^{-1})	(> 23 km·h^{-1})
	2018	20	18	GPS			(n)

DeWitt et al (11)			American National	(10 Hz)	8883 ± 1877	570 ± 407	9 ± 11
						(16-20 km·h^{-1})	(> 20 km·h^{-1})
FIFA (16)	2016	52	438 24 National teams International	Prozone Sports (25 Hz)	10717	826	445
						(18-21 km·h^{-1})	(> 21 km·h^{-1})
FIFA (14)	2012	32	400 16 National teams International	Amisco Pro (25 Hz)	10215	395	290
							RS (n/match)

Gabbett et al (18)	2013	5 International 10 National	15 International 19 National Australian	Time motion analysis			International 9.5 National 9.6		
						(12-19 km·h^{-1})	(> 19 km·h^{-1})		
Hewitt et al (20)	2014	13	15 Australian International	GPS (5 Hz)	9631 ± 175 1st Half 4936 ± 78 2nd Half 4695 ± 108	2407 ± 125 1244 ± 61 1163 ± 71	338 ± 30 173 ± 15 165 ± 18		
								(> 2 m·s^{-2})	(< -2 m·s^{-2})
Mara et al (26)	2017	7	12 Australian National	Optical Player Tracking (25 Hz)				423 ± 126	430 ± 125

						(12-19 km·h^{-1})	(> 19 km·h^{-1})	
Mara et al (27)	2017	7	12 Australian National	Optical Player Tracking (25 Hz)	10025 ± 775	2452 ± 636	615 ± 258	
						(17-20 km·h^{-1})	(> 20 km·h^{-1})	(> 2.3 m·s^{-2})
Meylan et al (30)	2017	34	13 Canadian International	GPS (10 Hz)	107 ± 16.3 m/min	6.0 ± 2.1 m/min	2.9 ± 1.2 m/min	1.8 ± 0.7 /min
							(> 20 km·h^{-1})	
Nakamura et al (31)	2017	10	11 Brazilian National	GPS (5 Hz)			285 ± 164 (n) 18 ± 10	

						(16-20 $km\cdot h^{-1}$)	(> 20 $km\cdot h^{-1}$)	(> 1 $m\cdot s^{-2}$)	(< -1 $m\cdot s^{-2}$)
Ramos et al	2017	U17 7	14	GPS	8270	484	190	171	102
(34)		U20 7	14	(10 Hz)	8704	687	223	184	126
		Senior 6	17		10110	755	306	214	174
			Brazilian						
			International						
						(> 16 $km\cdot h^{-1}$)	(> 20 $km\cdot h^{-1}$)	(> 2.3 $m\cdot s^{-2}$)	
Trewin et al	2018	55	45	GPS			(n)		
(44)			Canadian	(10 Hz)	10368 ± 952	930 ± 348	20 ± 9	174 ± 33	
			International						
						(17-20 $km\cdot h^{-1}$)	(> 20 $km\cdot h^{-1}$)	(> 2.3 $m\cdot s^{-2}$)	
Trewin et al	2018	30	45	GPS			(n)		
(43)			Canadian	(10 Hz)	107 ± 10	9.5 ± 3.2 m/min	0.2 ± 0.1 /min	1.8 ± 0.4 /min	
			International		m/min				

						(15-18 km·h^{-1})	(> 18 km·h^{-1})
Turner (45)	2016	1	11 Non-elite	GPS	8906 ± 1000	772 ± 171	482 ± 317
			14 Sub-elite	(5 Hz)	9717 ± 751	658 ± 190	410 ± 193
			9 Elite		9811 ± 738	872 ± 162	651 ± 195
			English				
						(16-20 km·h^{-1})	(> 20 km·h^{-1})
Vescovi and Falenchuck (49)	2019	9	28 American National	GPS (5 Hz)		8.4 ± 0.4 m/min	4.0 ± 0.4 m/min
						(16-20 km·h^{-1})	(> 20 km·h^{-1})
Vescovi (48)	2014	15	National	GPS	8558 ± 223	658 ± 54	235 ± 33
			U17	(5 Hz)	100 ± 3 m/min		(n)
							13 ± 2

					(> 25 km·h^{-1})
Vescovi (47)	2012	12	71	GPS	1st Half
			American	(5 Hz)	62 ± 55
			National		2nd Half
					49 ± 51

All data are expressed as mean ± standard deviation if provided by original research.

* Value represents sum of zones provided, whereby the SD is calculated from the multiple SD provided from the original research.

GPS = global positioning system; HSR = high-speed running; n = number; RS = repeated sprints.

Table 2. A summary of the positional movement patterns of football match-play.

Study	Year	Matches analysed	Subjects/ Nationality/ Competition level	Method of data collection	Total distance (m)	HSR (m)	Sprinting (m)	Accelerations (n)	Decelerations (n)
						(15-21 km·h^{-1})	(> 21 km·h^{-1})		
Bradley et al (2)	2014	Not provided	59	Amisco Pro (25 Hz)	CD 10238 ± 226*	1116 ± 75*	216 ± 33*		
			European		WD 10707 ± 351*	1398 ± 132*	262 ± 46*		
			National		CM 11160 ± 254*	1456 ± 87*	266 ± 31*		
					WM 10929 ± 417*	1508 ± 126*	369 ± 67*		
					A 10766 ± 359*	1401 ± 93*	506 ± 100*		
						(20-25 km·h^{-1})	(> 25 km·h^{-1})		
	2017	10	107		CD 9498 ± 562	423 ± 79	111 ± 42		

Datson et al (8)			13 National teams International	Prozone Sports (25 Hz)	WD 10250 ± 661 CM 10985 ± 706 WM 10623 ± 665 A 10262 ± 798	634 ± 168 683 ± 170 700 ± 167 651 ± 135	163 ± 79 170 ± 69 220 ± 116 221 ± 53
Datson (7)	2016	10	107 13 National teams International	Prozone Sports (25 Hz)		RS (20-25 km·h^{-1}) (n) CD 22 ± 5 WD 33 ± 8 CM 38 ± 8 WM 40 ± 9 A 37 ± 9	RS (> 25 km·h^{-1}) (n) 0.6 ± 0.7 0.9 ± 0.9 1.6 ± 1.2 1.4 ± 1.3 1.4 ± 1.4

						(18-23 $km \cdot h^{-1}$)	(> 23 $km \cdot h^{-1}$) (n)
DeWitt et al	2018	20	18	GPS			5 ± 8
(11)			American	(10 Hz)	CD 7871 ± 1411	338 ± 238	9 ± 10
			National		WD 9303 ± 1594	581 ± 396	5 ± 8
					CM 9144 ± 1911	483 ± 348	15 ± 14
					A 9005 ± 2062	805 ± 438	
						(16-20 $km \cdot h^{-1}$)	(> 20 $km \cdot h^{-1}$)
FIFA (16)	2016	52	438	Prozone	CD 10020	607	318
			24 National	Sports	WD 10748	856	536
			teams	(25 Hz)	CM 11230	928	356
			International		WM 10902	927	575

					A 10781	891	565
						(n)	(n)
						CD 60	21
						WD 84	34
						CM 92	24
						WM 89	36
						A 88	36
						(18-21 km·h^{-1})	(> 21 km·h^{-1})
FIFA (14)	2012	32	400	Amisco Pro	CD 10160	335	260
			16 National teams	(25 Hz)	WD 10850	460	380
					CM 11350	440	285
			International		WM 11280	540	440

					A 10460	465	485		
						(n)	(n)		
						CD 40	21		
						WD 40	22		
						CM 39	16		
						WM 47	27		
						A 41	29		
								(> 2 m·s^{-2})	(< -2 m·s^{-2})
Mara et al (26)	2017	7	12 Australian National	Optical Player Tracking (25 Hz)				CD 342 ± 135*	356 ± 137*
								WD 431 ± 144*	443 ± 146*
								CM 465 ± 145*	473 ± 144*
								WM 475 ± 117*	474 ±108*

								A 413 ± 143*	409 ± 137*
						(12-19 $km \cdot h^{-1}$)	(> 19 $km \cdot h^{-1}$)		
Mara et al (27)	2017	7	12 Australian National	Optical Player Tracking (25 Hz)	CD 9220 ± 590	1772 ± 439	417 ± 116		
					WD 10203 ± 568	2569 ± 612	680 ± 278		
					CM 10581 ± 221	2761 ± 417	484 ± 169		
					WM 10472 ± 878	2917 ± 545	850 ± 178		
					A 9661 ± 602	2420 ± 405	841 ± 238		
							(> 20 $km \cdot h^{-1}$)		
Nakamura et al (31)	2017	10	11 Brazilian National	GPS (5 Hz)			CD 125 ± 61		
							WD 359 ± 98		
							M 359 ± 174		

							A 352 ± 145		
							(n)		
							CD 8 ± 3		
							WD 21 ± 5		
							M 22 ± 10		
							A 23 ± 8		
						(16-20 $km \cdot h^{-1}$)	(> 20 $km \cdot h^{-1}$)	(> 1 $m \cdot s^{-2}$)	(< -1 $m \cdot s^{-2}$)
Ramos et al (34)	2017	Senior 6	17 Brazilian International	GPS (10 Hz)	CD 10003 ± 954	590 ± 104	199 ± 91	218 ± 22	161 ± 19
					WD 10237 ± 665	840 ± 137	379 ± 119	214 ± 35	182 ± 23
					M 10377 ± 981	811 ± 207	299 ± 142	214 ± 17	178 ± 19
					A 9825 ± 894	783 ± 251	352 ± 125	210 ± 29	176 ± 27

						(16-20 km·h^{-1})	(> 20 km·h^{-1})	(> 2 m·s^{-2})	(< -2 m·s^{-2})
Ramos et al	2017	7	12	GPS	CD 8202 ± 514	509 ± 76	113 ± 44	13 ± 3	14 ± 3
(35)			Brazilian	(10 Hz)	WD 9073 ± 475	859 ± 99	331 ± 94	15 ± 6	19 ± 7
			International		M 8486 ± 703	552 ± 113	126 ± 48	14 ± 5	11 ± 4
			U20		A 9056 ± 460	830 ± 191	323 ± 111	17 ± 6	25 ± 9
						(> 16 km·h^{-1})	(> 20 km·h^{-1}) (n)	(> 2.3 m·s^{-2})	
Trewin et al	2018	55	45	GPS			14 ± 6		
(44)			Canadian	(10 Hz)	CD 9533 ± 650	661 ± 221	26 ± 9	187 ± 33	
			International		WD 10496 ± 822	1191 ± 314	20 ± 9	185 ± 27	
					M 10962 ± 750	973 ± 334	25 ± 9	158 ± 33	
					A 10380 ± 893	1037 ± 305		174 ± 27	

					(> 18 km·h^{-1})
Vescovi (47)	2012	12	71	GPS	D 545 ± 217
			American	(5 Hz)	M 447 ± 185
			National		A 657 ± 157

All data are expressed as mean ± standard deviation if provided by original research.

* Value represents sum of zones provided, whereby the SD is calculated from the multiple SD provided from the original research.

A = attacker(s); CD = central defender(s); CM = central midfielder(s); D = defender(s); GPS = global positioning system; HSR = high-speed running; M = midfielder(s); n = number; RS = repeated sprints; WD = wide defender(s); WM = wide midfielder(s).